Small Smart Distributed Control System

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Abstract - This paper presents a small-scale smart distributed control system (DCS) based on RS-485 network. It discusses the network construction of the distributed control system, the characteristics of RS-485, how to construct typical RS-485 two wire multi-drop network and the details of the communication protocol. The smart controller based on dual MCUs can execute many kinds of the advanced control algorithms downloaded from the operating station. The controller has strong ability to deal with real-time response and great capacity of data processing, because of the dual MCUs structure. The control is stable and flexible, because the whole program which user has configured in the operating station is downloaded into RAM. The independent watchdog circuit is also designed.

I. INTRODUCTION

Distributed control system (DCS) is a very useful advanced automation device, but its price is very high. Although the DCS manufacturers in the world produce different kinds of small scale DCSs, the system is also expensive to the small enterprises in the developing country. To meet the needs of the small enterprises, we design a small-scale smart distributed control system which is cost-effective.

II. SYSTEM ARCHITECTURE

The whole system includes a PC or an IPC and several basic controllers. The PC as the operating station is used to configure function blocks and monitor the control process. Basic controller equipped with double CPUs is used to sample data and execute control algorithms. The communication system adopts EIA/TIA-485 Standard which is represented by RS-485. The above elements constitute the small scale DCS. The system architecture is shown in Figure 1. The operating station can be an

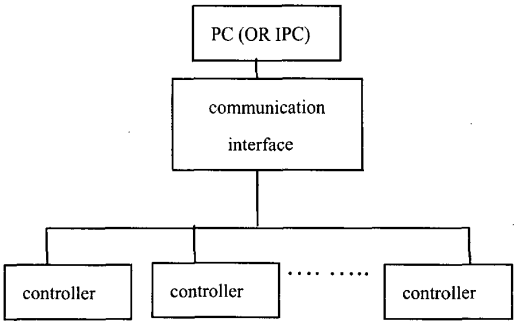

Figure 1. System block diagram

industrial computer with RS-485 interface or a PC with a RS232/RS485 converter in the serial port. We select the ADC-106 interface converter made by Atronix, which can transfer the signal transmitting in an RS-232 serial port into the balanced half-duplex RS-485 signal. There is also an RS-485 interface which adopts MAX485 transceiver made by MAXIM Corporation in each basic controller.

III. COMMUNICATION SYSTEM

Elements of the Communication Network

The data transmission of the whole system is in an RS-485 system. Fig. 2 is an example of a typical RS-485 two wire multi-drop network. The characteristics of RS-485 is as follows:

- The speed of RS-485 bus is quick and the maxim speed is 10Mbps.
- The distance of the bus is long. For example it can transmit data for 1200 meters by the speed of 90Kbps.
- It has the strong ability to eliminate common mode disturbance, because each signal is transmitted in a balanced data transmission system.
- Each generator or driver can drive up to 32 receivers.

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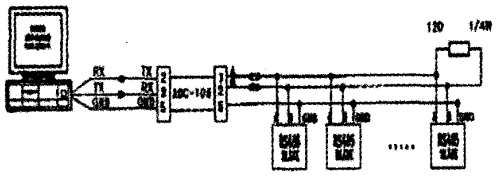

Figure. 2 Typical RS-485 two wire multi-drop network

Because of the above advantages, RS-485 is always chosen to transmit data in the industrial field control system. When construct an RS-485 network, it is necessary to have a termination match the impedance of a node to the impedance of the transmission line being used. When those impedances are not matched, the transmitted signal is not completely absorbed by the load and a portion of it is reflected back into the transmission line. The method to terminate data lines is to add a resistor in parallel with the receiver A and B lines in order to match the data line characteristic impedance specified by the cable manufacture (120Ω is a common value). ADC-106 RS-232 to RS-485 converter is made by Atronix Inc. The converter can be plug into RS-232C serial port of standard DB9 pins and be supplied power by TXD、DTR and RTS signals. The power voltage must be more than 5v. The network interface of the basic controller is MAX485, which is low-power transceiver for RS-485. Controlling the COMS chip is very simple. Driver Enable (DE) and Receiver Enable (RE) pins are included on MAX485. Usually, one of the output ports of the controller is connected to both DE and RE pins. When the logic of the port is low, the serial port is in the state of receiving. If sending the data, the output port logic must be made high. The typical operating circuit is shown in Figure 3.

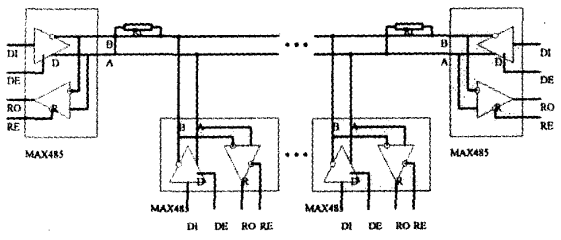

Figure. 3 Typical operating circuit of MAX485

Network Communication Protocol

The communication system between the PC and the controllers is strictly the master-slave type system in broadcasting mode. The slave nodes are not permitted to transmit data without a request from the master, and do not communicate with each other. The communication between the slave nodes is not direct. The message must firstly be stored into the master node, and then be forwarded to another slave node. Each slave must have a unique address so that it can be addressed independent of other nodes. The baud rate is 9600bps. The data frame consists of ten bits: a start bit (0), eight data bits (LSB first), and a stop bit (1). The data is in package form, and the format of the package is shown in Table I.PC (or IPC) broadcasts the address of the controller to be connected, and all controllers receive the address at the same time. Then each controller will compare the received address with its own address. If the address of the controller is the same as the received address, the controller is connected and the other controllers are isolated from the network. And now the network includes only the master node and the connected slave node so they can communicate with each other. The communication program flow chart is shown in Figure 4.

IV. DESIGN OF SMART CONTROLLER

The basic controller is the core of the hardware and the software of the whole control system. Whether the design of it is good or not will influence the usability、stability、and the ability of real-time response of the DCS. To meet the needs of the real-time response and the handling of

TABLE I

The format of the data package

start byte	Sour-ce adder-ss	Destinat-ion address	Leng-th of pack a-ge	Cont-ent of pack age	Chec-k sum	stop byte
One byte	two bytes	two bytes	two bytes	N bytes	two bytes	one byte

data in large quantity, we design a smart controller based on double MCUs. One MCU deals with data sampling and real-time control, and the other deals with data transmission. The data exchange between the two CPUs is through the dual-ram (IDT7132). There are 8 analog input channels、6 analog output channels(including 2 PWM channels)、16 digital input channels、16 digital output channels、and 2 pulse input channels. Its block diagram is shown in Figure 5. The master CPU deals with data sampling and signal processing and receives the configuring program downloaded by the operating station. Because the program downloaded form the PC executes in RAM, the control of the system is very flexible. The controller can execute advanced control algorithms. And the functions of modifying parameters on-line and giving an alarm can be included also. Therefore the controller can be made smart. The slave CPU is used for communication. It can receive the message from the operating station and then send the message to the master CPU. If the master CPU sends data to the PC, it must send the data to the slave CPU first. So the message exchange between the PC and the master CPU must pass the slave CPU.

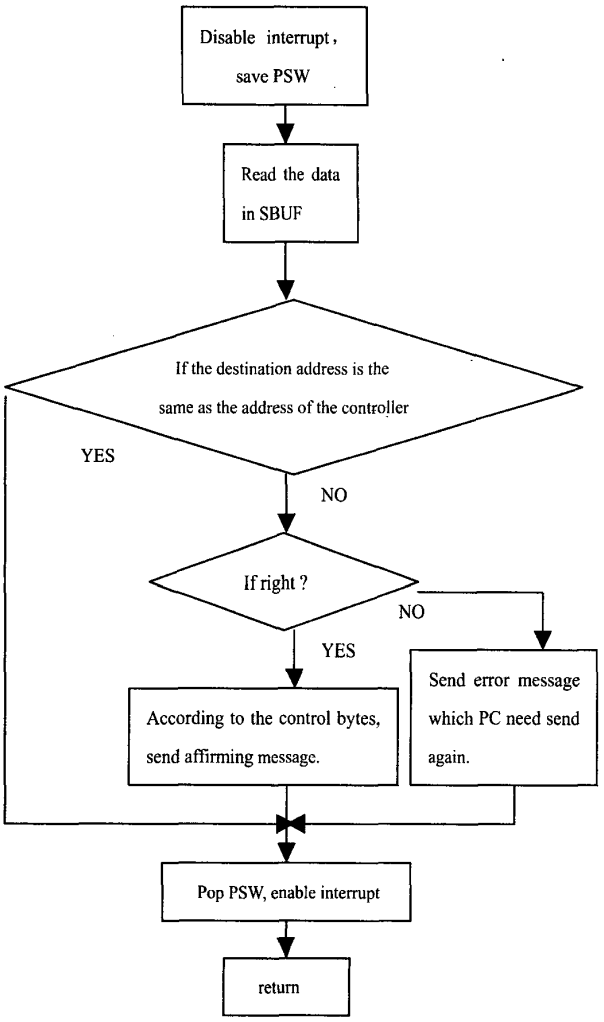

Figure. 4 Flaw chart of communication program

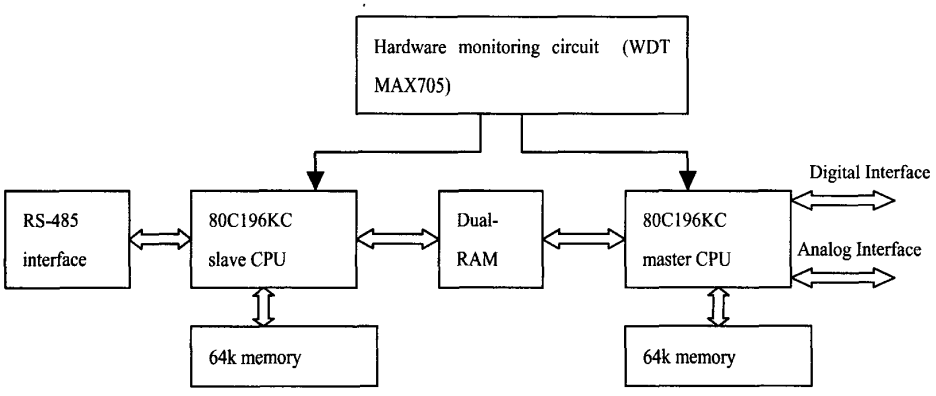

Figure. 5 Block diagram of the smart controller

V. CONCLUSIONS

From above discussion, it is clear that the controller has these advantages.

•The controller has good performances because of its dual-CPU structure.

•The controller is flexible, because the whole program is downloaded from the operating station.

•The watchdog circuit (MAX705) is independent, which can not only monitor the executing program but also monitor the power-supply. The circuit significantly improves system stability.

VI. REFERENCES

[1] EORGE J. BLICKLEY, "Distributed Control Systems: New and Improved at ISA/85", Control Engineering, vol.32, no.9 September 1985, pp150-152

[2] Michael Babb, "Distributed Process Control System Integrates Process Design and Control", Control Engineering, vol.32, no.12, November 1985, pp.81

[3] RS-422 and RS-485 Application Note, B&B Electronics Mfg. Co. Inc, October 1997

[4] Guo Moufa and Wang Shaobo, "The Design of RS-485 Network and Its Applications in Industrial Monitoring Systems", *Journal Of Fuzhou Universtity*, Vol.27, No.1, 1999

[5] *8x196kc/kd User's Manual*, Intel Inc. 1992